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Spectral characteristics of peanut crop infected by late leafspot disease under rainfed conditions

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ABSTRACT

A leafspot susceptible peanut cultivar (*cv JL 24)* was sown during *kharif* season of 2005 in rainfed region of Andhra Pradesh, India. Five disease levels (scale 0-4) were created in the field by differential fungicidal spray schedule, and each treatment was replicated four times. Spectral data was recorded at 2 nm intervals using a portable spectroradiometer within a spectral range of 300-1100 nm. The loss of leaf pigments (Chlorophyll a & b) due to diseases was quantified using spectrophotometer. The red and infrared reflectance values between 620- 680 and 770-860 nm, respectively were used for calculating Normalized Difference Vegetation Index (NDVI). Significant reduction in chlorophyll content was observed only when the disease reached a stage of scale 2 and above. The ratio of chlorophyll a to b showed a declining trend as the number of spots per leaf increased. From the spectral reflectance studies typical chlorophyll absorption bands (350 – 500 and 620-690 nm) of healthy and diseased plants could not be differentiated. However, the difference was evident in the chlorophyll reflection bands (522- 600 nm). The infrared spectral region between 700-850 nm was found to be sensitive to canopy disease stress. The reflectance (%) in this part of spectrum was higher for healthy plants compared to diseased plants. But, the low level of disease intensity (scale 1) was not differentiated by the spectral reflectance. The NDVI value for 82 days old healthy crop was in the range of 0.45 to 0.50, while the same for diseased plants was between 0.34 and 0.45. This study finds potential application of remote sensing techniques in detection of plant diseases.

Keywords: Peanut, leafspot disease, spectral characterization, remote sensing

1. INTRODUCTION

Peanut, also known as groundnut (*Arachis hypogaea* L.) is one of the important oil seed crops of India, which is cultivated in 6.7 million hectares and contributes about 7 million tones to the total oil seed production. The average yield per hectare in India is 1.07 tonnes, which is very low compared to many other countries (13). About 82 per cent of the crop is in the rain-dependent farming system in the arid and semi arid tropics of India. One of the major production constraints in groundnut in these regions is loss due to pests and diseases. Late leafspot (LLS) caused by fungus, *Cercosporidium personatum* (Berk. And Curt.), is a serious disease on groundnut and the damage of which can cause economic losses in both Asia and Africa (1). The losses have been attributed to reduction in leaf area index caused by leaf necrosis and defoliation. Reduction in light interception and canopy photosynthesis due to defoliation leads to

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decreased pod growth and increased pod loss (7-9). Hence, timely detection and control of this disease very crucial for avoiding economic losses. Manual scouting is laborious, time consuming, difficult to cover large areas and often leads to erroneous results due to visual assessment of the disease intensity. Considerable progress has been made during the past two decades in using multipsectral radiometers for quantifying pest and disease intensity in several crops (4,5,9). Earlier studies using spectroradiometer in peanut showed a linear relationship between percent reflectance values and leafspot and rust disease (6,7). The present study was carried out to characterize the spectral signatures of the peanut crop under stress due to leafspot disease using narrow bandwidth spectroradiometer and find the feasibility of using this technique for early detection of the disease.

2. METHODOLOGY

2.1 Creating differential disease intensity levels

A leafspot susceptible peanut cultivar (*cv JL 24)* was sown on 29 June 2005 in the rainfed region of Andhra Pradesh, India. The soil in the experimental site is shallow (30 to 50 cm), typic haplustalf (red sandy loam), with organic carbon content (OC) of 0.4%. The crop was given recommended doses of fertilizers and all other agronomic practices were followed. The crop was raised completely under rainfed conditions and hence no irrigation was provided. Two weeks after sowing, during the second week of July, when the crop was at 10-12-leaflet stage, the entire field was divided into plots measuring 7 X 7 m size. A total of 35 plots were available for conducting the experiments. Four differential fungicidal spray schedules using foliar sprays of carbendezim 50 WP and chlorothalonil 75 WP were followed to create difference in disease severity among the plots. Four healthy plots free of pests and diseases were maintained by treating seeds with carbendezim 50 WP and chlorpyriphos 20 EC before sowing and alternate foliar sprays of chlorothalonil 75 WP and neem seed extract 5% at weekly intervals, starting from 50 days after sowing. The incidence of LLS, also known as *tikka* disease was first recorded during the last week of August in the untreated plots and further intensified with time. The disease intensity was recorded on a 0-4 scale (0- no incidence, 4- high incidence) from individual plots at weekly intervals.

2.2 Estimation of leaf pigments

Spectral reflectance of crop canopies is primarily influenced by leaf pigments. Hence changes in leaf pigments, particularly chlorophyll as induced by the late leaf spot disease was estimated. The first fully opened leaf of the main axis from 5 randomly selected plants was collected. The leaf samples were drawn from plants with varying disease intensities (spot numbers per leaf ranging from 1 to > 6) and were immediately carried into iceboxes to avoid desiccation and changes in the pigment concentration during transit. The pigments (chlorophyll a & b) were extracted in the laboratory from healthy and diseased leaves using DMSO (dimethyl sulphoxide) method (11) and were quantified using spectrophotometer (12).

2.3 Recording spectral reflectance data

Spectral data were recorded at 2 nm (nominal) intervals using the portable spectroradiometer (LI-1800, LICOR) over a 300-1100 nm range. Reflectance measurements were recorded from individual plots at 7-10 days interval starting from 31st August, during cloud free days. All the measurements were made near midday, within 2 hrs of solar noon. The measurements were taken from a height of 1.6 m above the crop canopy. Five measurements were recorded per plot and the resulting data were averaged. Reflectance standard measurements were made from barium sulfate plates immediately before and after crop canopy measurement in each plot. Reflectance spectra, relative to barium sulfate standard, were calculated by dividing canopy radiance by reference radiance from barium sulfate standard for each wavelength. The incremental values of spectral reflectance were averaged within 490 to 560, 620 to 680 and 770 to 860 nm to give values of green (GRN), red (RED) and near infrared (NIR) bands respectively. Simple ratio, normalized difference vegetation indices (NDVI & GNDVI) and other indices such as soil adjusted vegetation index (SAVI) and optimized SAVI (OSAVI) were calculated by suing the following formulae:

Simple ratio	:	NIR/RED
Normalized difference vegetation index (NDVI)	:	(NIR-RED)/(NIR+RED)
Green NDVI	:	(NIR-GRN)/(NIR+GRN)
Soil adjusted vegetation index (SAVI)	:	(1+0.5)(NIR-RED)/(NIR+RED+0.5)
Optimized SAVI	:	(NIR-RED)/(NIR+RED+0.16)

3. RESULTS

3.1 Leaf pigment changes due to leafspot disease

It is inferred from the results that there is not much change in total chlorophyll content between healthy and diseased leaflets having spots up to 4 per leaf. Whenever the disease reached a stage of 4 spots per leaf and above, there was sudden decrease in the total chlorophyll content. However, the ratio of chlorophyll a to b showed a gradual decreasing trend, proportion to the number of spots per leaf. This indicates that the plants photosynthetic efficacy is being affected when it is subjected to stress. Presence of disease may cause changes in pigment concentration and variation in canopy gas exchange, leading to difference in colour and temperature that alter canopy reflectance characteristics (4).

Table. 1. Changes in leaf pigments due to late leafspot disease in groundnut (mg/g fresh wt of leaf)

	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Ratio of a:b
Healthy	1.212	0.242	1.455	5.001
1 spot/ leaf	0.950	0.241	1.191	3.951
2 spots/leaf	1.006	0.211	1.217	4.775
3 spots/leaf	1.460	0.341	1.801	4.286
4 spots/leaf	1.320	0.376	1.695	3.512
4-6 spots/leaf	0.438	0.223	0.661	1.965
>6 spots/leaf	0.402	0.192	0.594	2.094
SD±	0.410	0.070	0.470	1.220

Fig. 1. Healthy (right) and LLS diseased (left) peanut plants.

Fig. 2. Leaf samples with varying levels of disease.

3.2 Spectral signatures of diseased and healthy crop canopies

Though the spectral observations were planned at weekly intervals, due to frequent rains and cloudy weather during the season, the data recording was possible with only few dates. The spectral observations recorded on 8 September 2005 revealed difference in the percent reflectance between the healthy and diseased plants. The reflectance starting from 670 nm and above was high from healthy plants compared to the diseased plants. The typical chlorophyll absorption bands (350 – 500 nm and 620-690 nm) in the visible region of the spectrum could not be differentiated in the healthy and diseased plants. However, the chlorophyll reflectance bands (520-600 nm) could be distinguished in all the three dates of observations. Plant stress that causes reduction in chlorophyll leads to an increase in light reflected in the visible range (400-700 nm). Conversely, percent reflection in the NIR region (740-1100 nm) is reduced as internal leaf structure degenerates. This scattering occurs deep within the leaf tissue, and hence percentage light reflected in the NIR region may provide information on the physiological condition of plant under stress (4,5). Discontinuity between air spaces and plant cell walls leading to high internal light scattering coupled with reduced absorption causes increased NIR reflectance in healthy leaves (10).

The reflectance from the plots with initial stages of disease symptoms (scale 1) was not very different from the healthy plots. But the higher level of disease intensities (scale 2 and above) were differentiated based on the spectral reflectance curves of 29 September and 11 October 2005. The reflectance values between 700 to 850 nm were low from diseased plots compared to healthy ones. Radiometer at 800 nm wavelength measured the healthy green area and hence was found useful to screen peanut genotypes for resistance to late leafspot and to evaluate treatments for the control of the disease (6,7). Though the spectral reflectance curves delineated the healthy and diseased crop canopies, the severity of the disease to the extent of percent diseased area, particularly when the disease was in initial stages was not conclusive. The fungicide spray for the control of groundnut leafspot diseases is effective and economical only when it is applied before the disease crosses threshold level of 10 percent (3). Hence utility of this technique for early forewarning of disease i.e., before the disease crosses threshold level, needs to be carefully ascertained. However, in practice, this technique has potential use in area-wide detection and management of LLS, especially in large contiguous groundnut tracts such as Anantapur district of Andhra Pradesh, where farmers often resort to late application of fungicides, long after crossing disease thresholds.

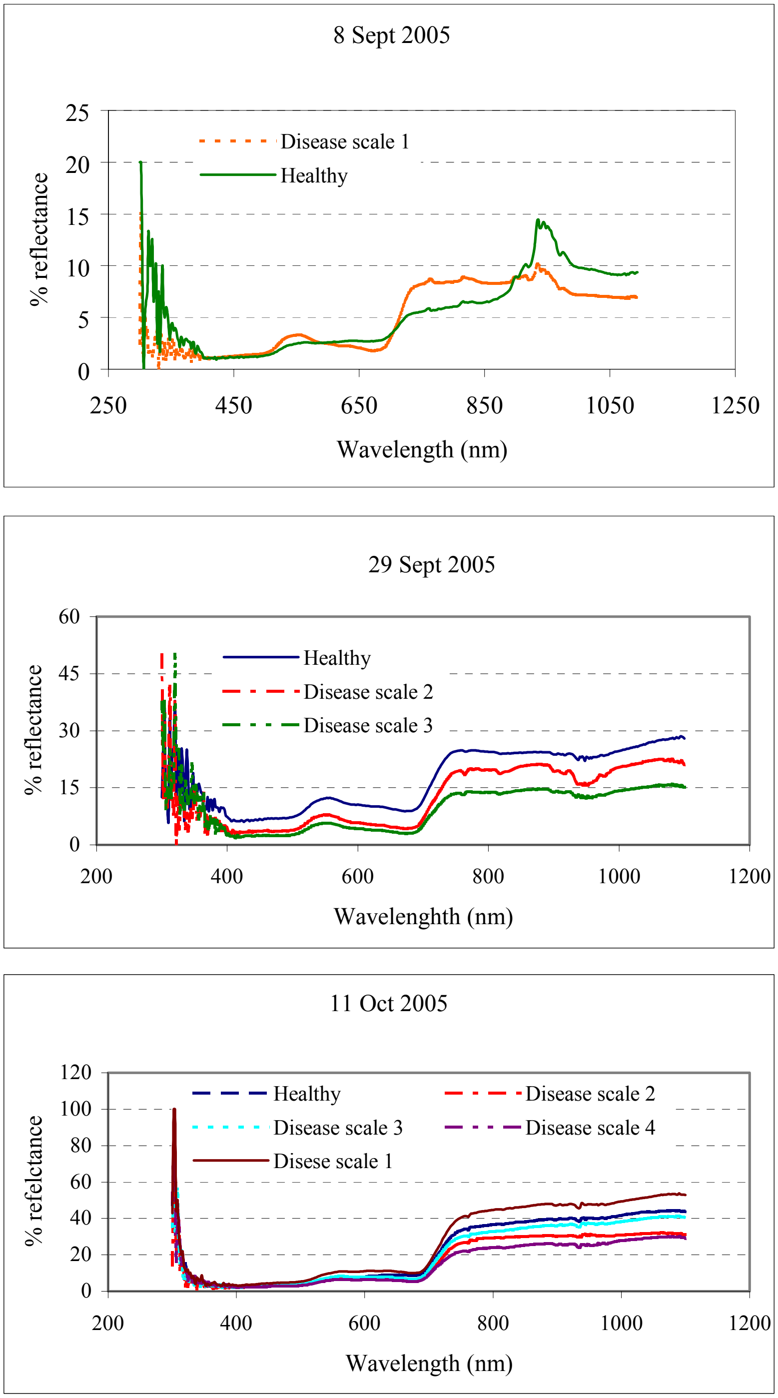

Fig. 3. Spectral signatures of LLS infected peanut crop canopies at different dates

3.3 Spectral indices of diseased and healthy crop canopies

The NDVI values for healthy plants was in the range of 0.45 to 0.50 in four different dates of observation, while the same for diseased plants was between 0.34 and 0.45. The Green NDVI is also low for diseased plants (except on 8 Sept.). The SAVI and OSAVI followed similar trend. Spectral indices were used by many others as indicators of plant condition and yield assessment (2).

Table. 2. Spectral indices of healthy and diseased plants of groundnut

	Index	Healthy plants	Diseased plants
8-Sep-05	Simple ratio	2.7205	2.0588
	NDVI	0.4624	0.3461
	Green NDVI	0.5377	0.5645
	SAVI	0.5633	0.3484
	OSAVI	0.4305	0.2992
29-Sep-05	Simple ratio	2.8495	2.3165
	NDVI	0.4804	0.3937
	Green NDVI	0.5385	0.4687
	SAVI	0.4911	0.4245
	OSAVI	0.4179	0.3498
5-Oct-05	Simple ratio	2.6941	2.2681
	NDVI	0.4553	0.3492
	Green NDVI	0.5168	0.4741
	SAVI	0.5379	0.5064
	OSAVI	0.4182	0.3480
11-Oct-05	Simple ratio	3.0800	2.6989
	NDVI	0.5098	0.4530
	Green NDVI	0.7060	0.6809
	SAVI	0.3344	0.2517
	OSAVI	0.3611	0.2758

4. CONCLUSIONS

Canopy reflectance recorded with portable spectroradiometer in the regions between 520-600 nm and 700 – 850 nm provided information on the severity of late leafspot disease in peanut. It offers scope for potential use this technology to distinguish healthy and diseased areas in a rapid and cost effective manner from large and contiguous groundnut tracts. However, further studies are required to use this technique for detection of the disease in its initial stages of development so as to provide early forewarning and site-specific fungicide spray advisory.

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